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PROJECTILE, 76MM/62 CALIBER, MK -- FROM AISI 9260 STEEL

Naval Weapons Laboratory
Dahlgren, Virginia

25 September 1974

PROJECTILE, 76MM/62 CALIBER, MK— FROM AISI 9260 STEEL

FINAL REPORT

Contract N00178-74-C-0030

PUBLISHED BY DIRECTION OF
NAVAL WEAPONS LABORATORY

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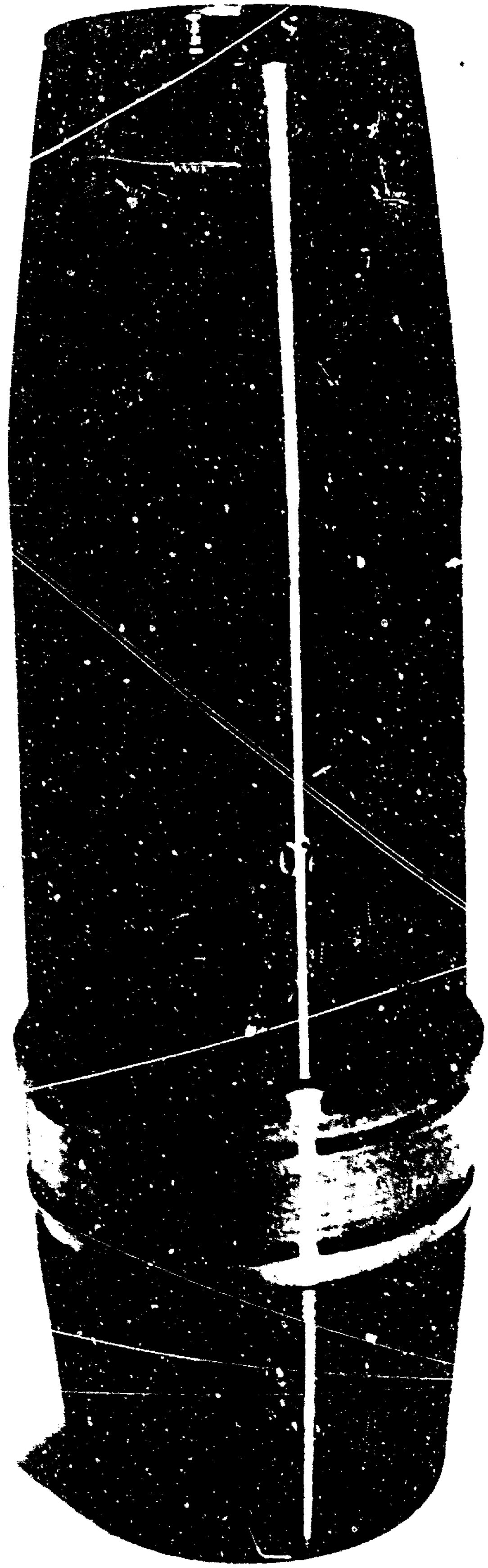

PHOTOGRAPH NO. 10033
NAVY 76 MM/62 CALIBER PROJECTILE FROM AISI 9260 STEEL

FINAL REPORT

CONTRACT N00178-74-C-0030

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FINAL REPORT

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1. INTRODUCTION AND BACKGROUND

1.1 Effective 12 September 1973 the Chamberlain Manufacturing Corporation Research and Development Division contracted to produce the following quantities of 76-mm/62 Caliber Projectiles and associated parts:

<u>Item 0001</u>: 5,050 each Projectile Bodies, Drawing 07609-40726 Rev. B (Later Rev. C)

<u>Item 0002</u>: 250 each Projectile Bodies, Drawing 07609-41095

<u>Item 0003</u>: 250 each Base Plug, Drawing 07609-40890

<u>Item 0004</u>: 2,000 each Cavity Liners, Drawing 07609-40727 Rev. B

Essentially this was a follow-on effort to Contract N00178-73-C-0373 during which the Company fabricated experimental quantities of projectiles from both HF1 and AISI 9260 steel. Under the subject contract, the material for the projectile body was AISI 9260 steel, the first quantity of which was furnished by the U. S. Naval Weapons Laboratory.

1.2 A Description of Manufacture was submitted on 29 May 1974 which discussed and described the process employed by Chamberlain to manufacture the above quantities. Attached thereto was a Detailed Plan of Inspection. Briefly, each component was produced as described in the following paragraphs.

1.2.1 Body

The projectile body was manufactured over general purpose equipment available in the shops of the Research and Development Division. Inspection was conducted using a combination of Government-furnished gages and free setups or Company gages for those characteristics for which no Government-furnished gages were available.

The basic body process is the hot cup-cold draw process, using AISI 9260 steel which was certified to the following chemistry by Republic Steel Corporation.

Heat Lot	BHN	C	Mn	P	S	Si
8081261	8	.605	.90	.007	.016	2.06

Forge temperatures were over the critical transformation temperature of the material; therefore, it was necessary to ascertain that the material was fully spheroidize annealed prior to conducting cold drawing operations. After each cold draw, the material was annealed back for subsequent draws. Cleanliness is important; therefore, the Company places considerable emphasis on shot blast cleaning to remove scale and to furnish a good base for lubricant required to accomplish draws.

The remainder of the process is conducted on general purpose machining equipment.

1.2.2 Rotating Bands

Band blanks measuring 3.0 inches I.D. by .225 inch wall were purchased from Chase Copper and Brass Co., Waterbury,

Connecticut. The material is annealed commercial bronze (90% copper) and was certified as follows per Mil-B-18907 (NOrd).

Sample	Grain Size (mm)	Tensile Strength (psi)	% Elongation (2 In.)	180° Bend	Cu	Pb	Fe	Zn
1	.060	36,800	54	OK	89.63	.03	.03	Balance
2	.060	35,400	50	OK				

Blanks were applied to bodies with a Watson-Stillman 24-Jaw banding press and then were final machined.

1.2.3 Cavity Liner

These were purchased fully machined from Nieman Tool and Machine Co. and the 2-1/8 inch diameter 6061-T6 aluminum rod they used was certified to meet Mil-QQ-A-225/8 by Hubbell Metals, Inc. and Industrial Testing Laboratories, Inc. The following data apply to the cavity liners manufactured under this contract.

Material Chemistry

Si		Fe	Cu		Mn	Mg		Cr	
Min.	Max.	Max.	Min.	Max.	Max.	Min.	Max.	Min.	Max.
.4	.8	.7	.15	.4	.15	.8	1.2	.04	.35

Zn	Ti	Other		Al
Max.	Max.	Each Max.	Total Max.	
.25	.15	.05	.15	Remainder

Mechanical Properties

	Specification	Actual
% Area Reduction	---	42.3
Yield Strength (psi)	35,000 Min.	40,610
Tensile Strength (psi)	38,000 Min.	44,970
% Elongation in 2 Inches	10 Min.	16

These items were shipped separate from projectile bodies.

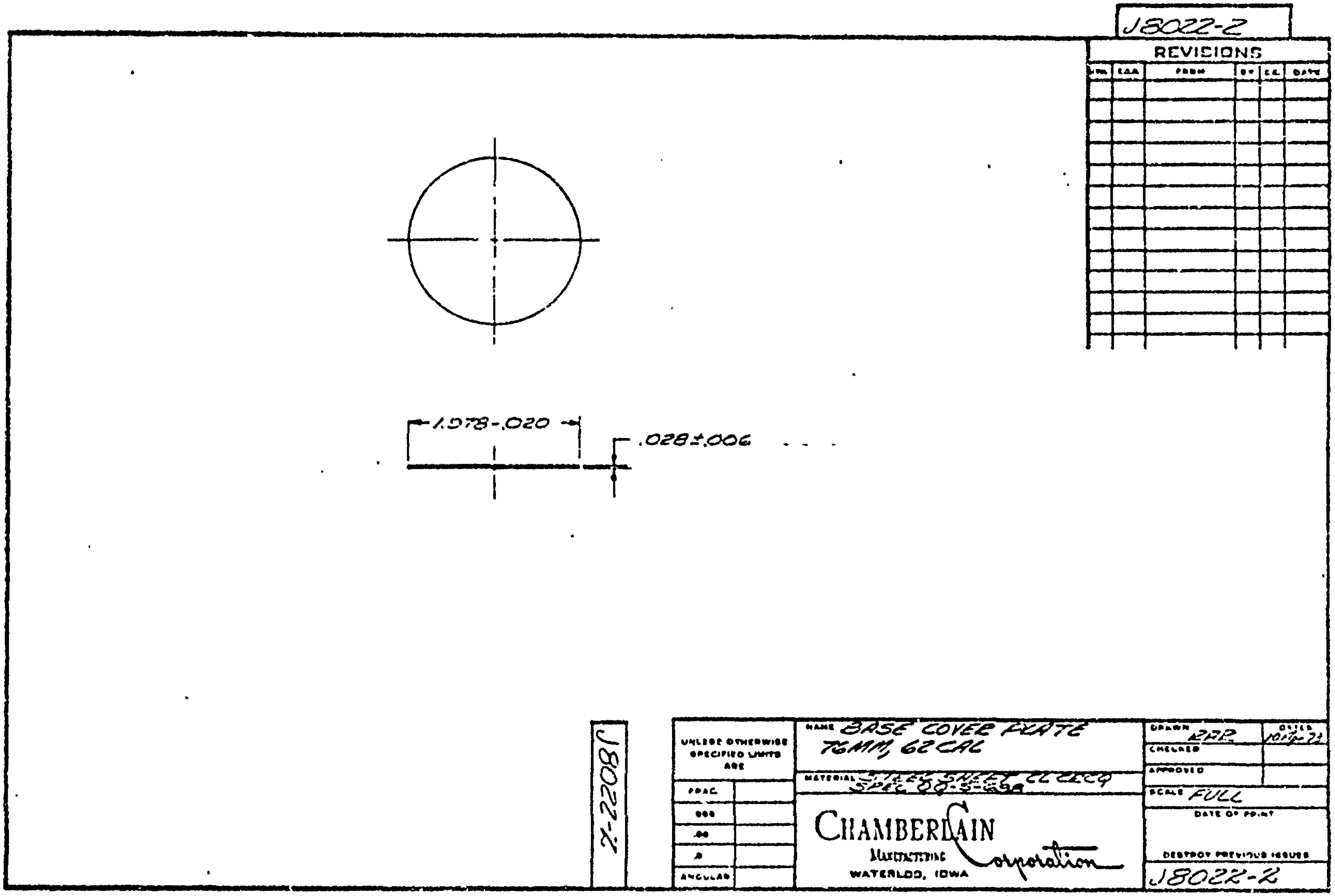
1.2.4 Base Cover Plates

These were procured already blanked from Tempco Manufacturing Co., Inc. Parts were blanked from .028±.006 inch thick cold rolled steel. The vendor furnished a notarized statement that the material met Mil-QQ-S-698. These were seam welded to the projectile bases with a Thompson welder furnished by the Government.

1.3 Applicable Drawings

1.3.1 Chamberlain-generated metal parts drawings for release to the shops appear on Pages 5 through 7. A process schematic is presented on Page 8. Per terms of the contract projectile bodies were inspected ultrasonically at destination. The final 3,800 bodies were inspected employing Government-furnished gages.

(Text Continued On Page 9)


J8022-2
REVISIONS
1.978-.020
.028±.006
UNLESS OTHERWISE SPECIFIED LIMITS ARE
FRAC.
.000
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ANGULAR
NAME BASE COVER PLATE 76MM, 62 CAL
MATERIAL
CHAMBERLAIN Manufacturing Corporation
WATERLOO, IOWA
DRAWN RRP
CHECKED
APPROVED
SCALE FULL
DATE OF PRINT
DESTROY PREVIOUS ISSUES
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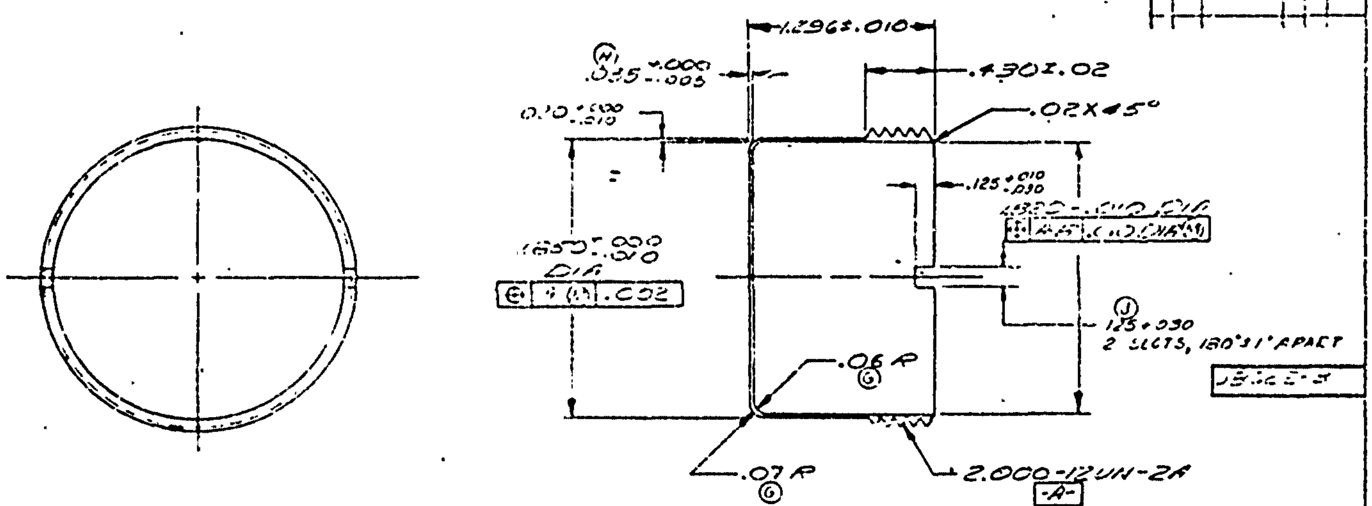
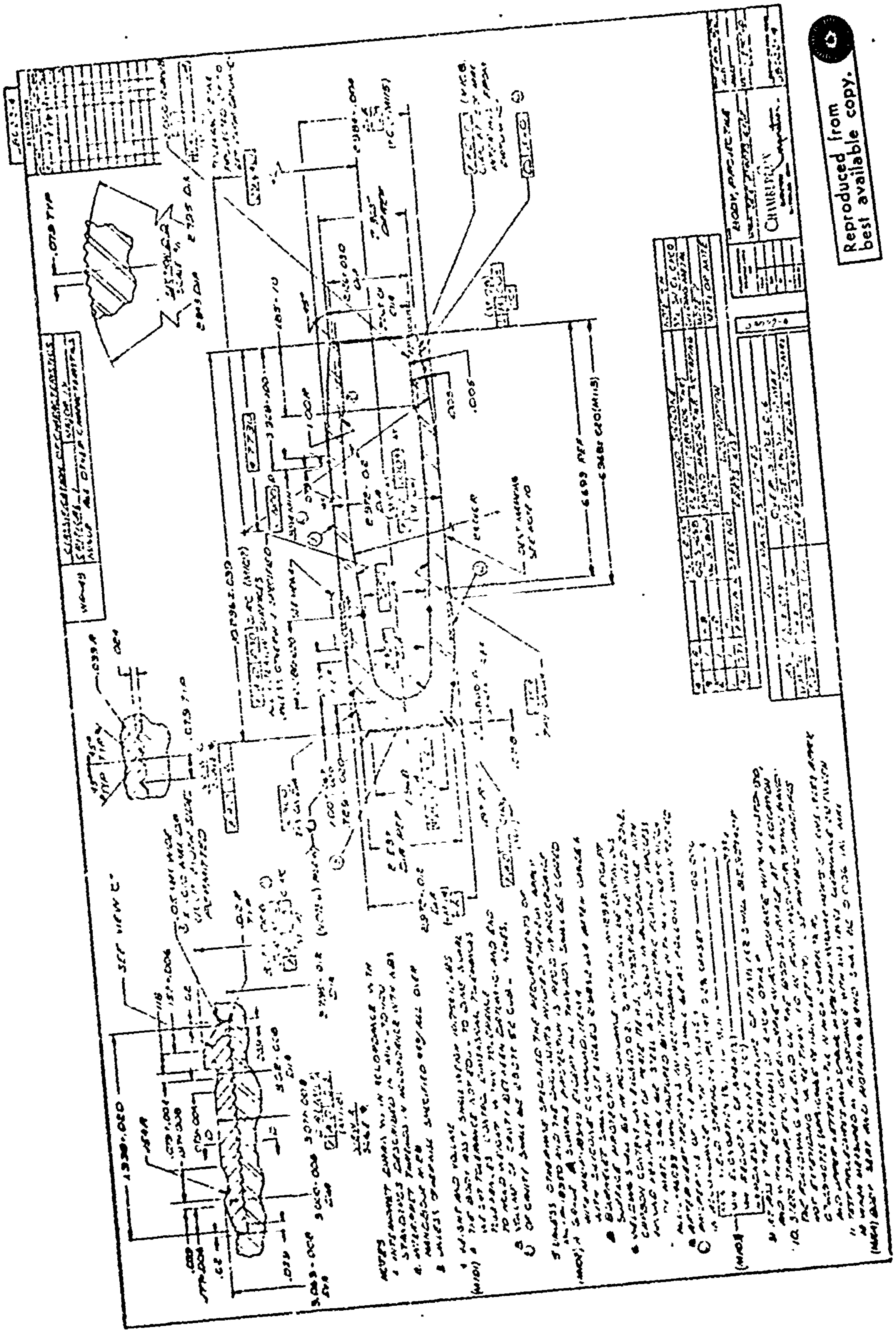
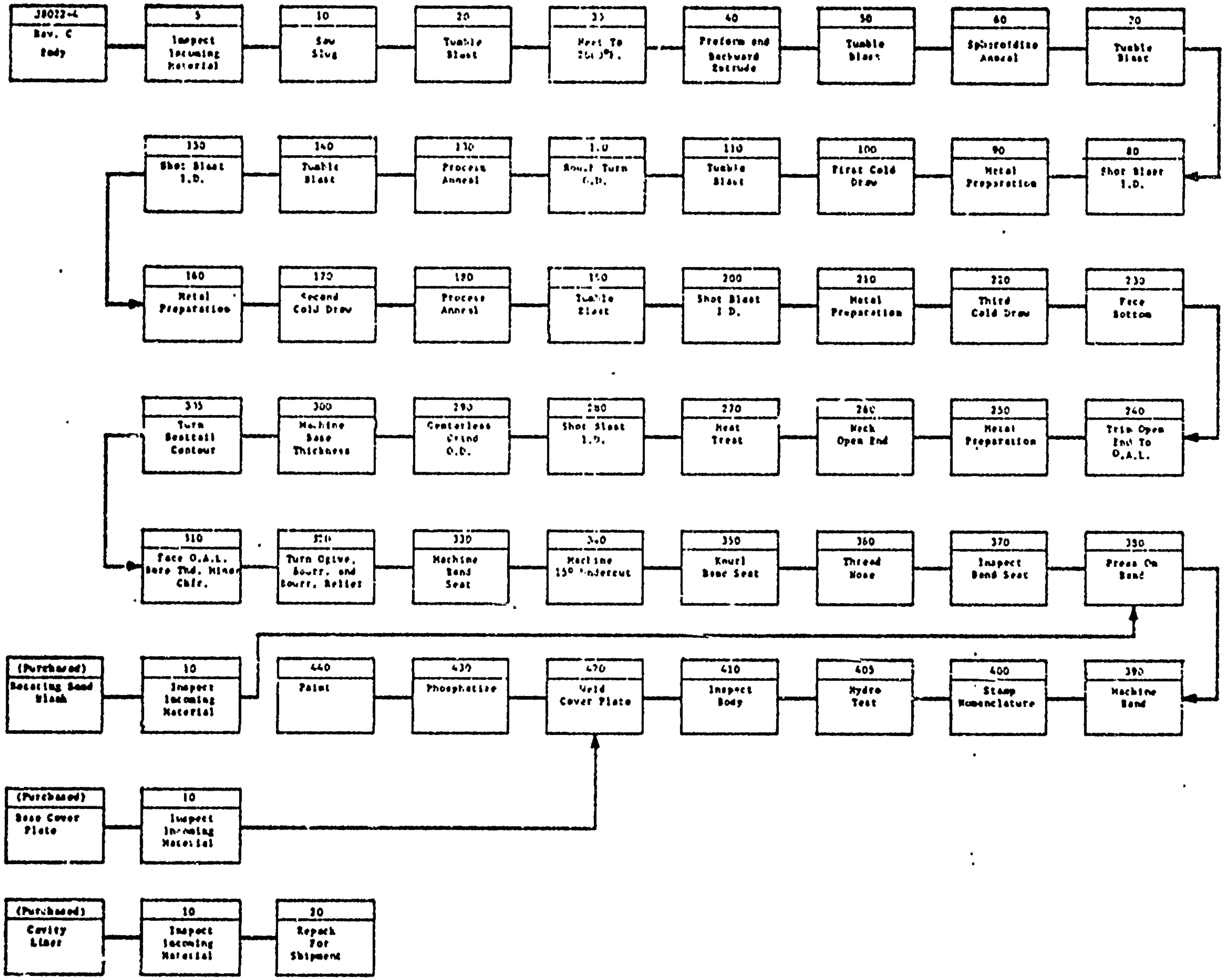


NOTES
1. INTERPRET DRAWING IN ACCORDANCE WITH MIL-STD-100.
2. UNLESS OTHERWISE SPECIFIED:
   125/ ALL OVER.
   REMOVE BURRS AND BREAK SHARP EDGES .01 MAX.
3. LINER MATERIAL SHALL BE ALUMINUM ALLOY 6061 MANUFACTURED IN ACCORDANCE WITH ANY ONE OF THE FOLLOWING SPECIFICATIONS:
   A QQ-A-250/11 - PLATE AND SHEET
   B QQ-A-200/8 - EXTRUDED BAR, ROD, SHAPES TUBE AND WIRE.
   C QQ-A-225/8 - ROLLED, DRAWN, OR COLD FINISHED BAR, ROD, AND WIRE.
4. AFTER HEAT TREATING IN ACCORDANCE WITH MIL-H-6088 FINAL MECHANICAL PROPERTIES SHALL BE AS FOLLOWS WHEN TESTED IN ACCORDANCE WITH ASTM E8 FLAT TEST SPECIMENS:
   A MIN YIELD STRENGTH (PSI) (AT 2% OFFSET) - 35,000.
   B MIN ELONGATION (%) IN 1.0 INCH - 5%
5. MARK THE FOLLOWING LEGEND IN 3/16 IN. HIGH CHARACTERS ON THE INSIDE CAVITY WALL USING RED STENCIL INK, TT-I-558 07603-40227 (APPLICATION REVISION LETTER) (SERIAL NO.) SERIAL NOS. SHALL BE ASSIGNED CONSECUTIVELY STARTING WITH .0001.
6. ALL LINER SURFACES SHALL BE CHROMIC ACID ANODIZED IN ACCORDANCE WITH MIL-A-8625C, TYPE I, CLASS 1, USING AN ORGANIC METAL PROTECTANT MIL-C-82554, TYPE II (KNOWN COMMERCIALLY AS CORROSIVE-1100). DIMENSIONAL LIMITS APPLY AFTER ANODIZING.

LINER, CAVITY

CHAMBERLAIN Corporation
HUDSON
WATERLOO, IOWA





MANUFACTURER'S FLOW DIAGRAM

2. DISCUSSION OF PROBLEMS

2.1 Chamberlain was not able to utilize all Government-furnished steel as efficiently as was anticipated. Approximately four to five inches of each bar could not be utilized because of distortion of bar ends caused by the nick and break operation performed by the Government's vendor. Thus, out of the initial shipment of 22,870 pounds (54 bars), only 1,375 forging slugs were grossed rather than the 1,500 anticipated. Another 200 forge slugs were acquired by transferring steel residual to Contract N00178-73-C-0373. The balance of material was received as a mill order.

2.2 During all cold drawing operations there were about 3.5% rejects for cracked cans. Examination of the cracks revealed in each instance a stringer or inclusion in the material as shown by Photograph 10226 on the following page. In a mass production situation this reject rate would be prohibitive, meaning that extra precautions will have to be exercised over material. The problem would not apply as readily to a hot forge-hot draw process -- only to a cold draw process such as used during the program.

Heat treating is a problem because the drawing specifies both mechanical properties and a hardness range. The two are not necessarily compatible, and one or the other should be eliminated from the drawing. Chamberlain Research and Development Division personnel prefer to work to a range of mechanical properties, with hardness as advisory only. Furthermore, for this item, the hardness range could be expanded to Rockwell "C" 26 to 36.

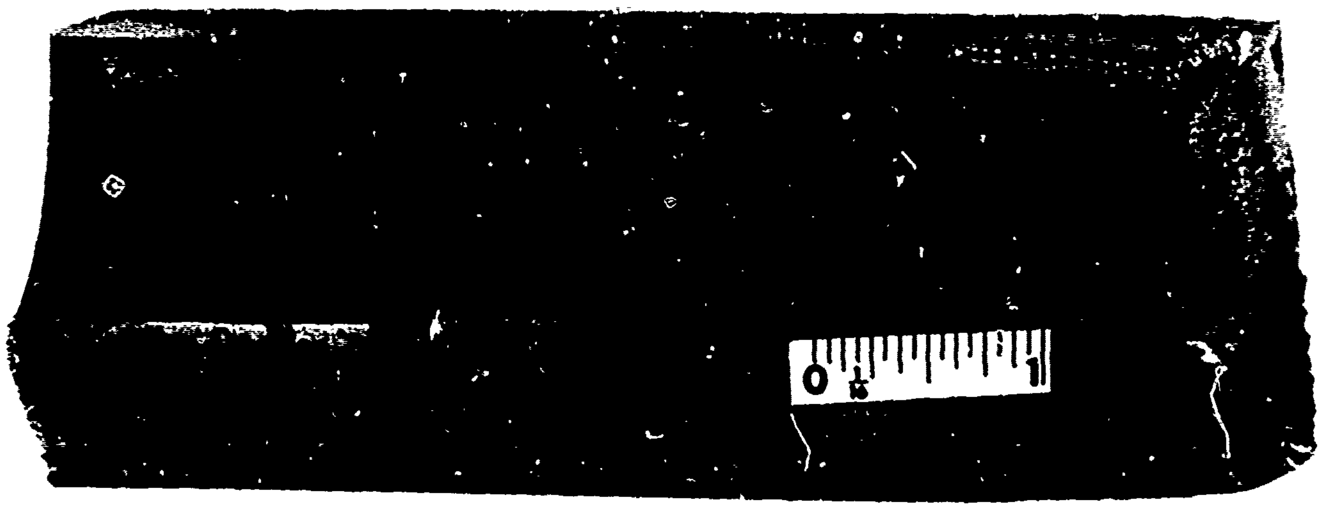


PHOTO NO. 10226

VIEW OF BROKEN COLD DRAWN 76MM/62 CAL. PROJECTILE BODY. DARK AREA AT EDGE SHOWS INCLUSION WHICH PRECIPITATED THE BREAK.

At the lower range, nose threads could be tapped rather than single point threaded. We realize that fragmentation characteristics may enter into consideration, and on that basis we do not make this a firm recommendation. However, the indication on the drawing should be to heat treat to either the mechanical properties or the hardness range.

Band seat machining proved troublesome because a special, rather expensive form tool had to be procured and there was a long elapsed lead time prior to receipt of the tool. The dovetail band seat undercut was split off from the grooving operation only because of equipment limitations at the time these projectiles were produced. Given larger quantities, Company engineers would rather add the undercut in the same chucking as groove cutting. The rather high ribs in the band seat were especially troublesome to knurl with standard shell knurling equipment and tooling. The O.D. of several setup bodies collapsed from tool pressure imposed by the rollers when the operator attempted to get a completely defined knurl to the bottom of each rib. A completely defined knurl was attained by knurling only 50% of the seat in a single pass. In this manner, pressure was reduced, but the operation took twice as long. The two-pass knurl met the print.

There was some divergent interpretation of the 1.850-.100 length for the nose thread. Company process engineers interpreted this as perfect thread length. Navy Quality Assurance personnel interpreted that the thread must proceed through the nose bore and tail off in the HE cavity. In order to do the latter, it was necessary to insert a hospital backbore operation

to trim excess material behind the thread. This was necessary because the existing Cri-Dan B single point thread lathe does not have sufficient stroke to pass through the entire nose area using the cam presently installed on the machine.

3. RESULTS

3.1 Deliveries

Several schedule modifications were processed during the course of the contract, reflecting material delivery adjustments. Tabulated below are shipments made on the contract.

Contract Line Item	Description	Quantity	Date Shipped
0001	Projectile Body 07609-40726 Rev. B	785	3 Dec 73
		138	11 Jan 74
		198	11 Jan 74
		80*	21 May 74
		129	17 Jun 74
		1,347	15 Jul 74
		1,078	19 Jul 74
		1 Hand Carried	25 Jul 74
		1,174	29 Jul 74
		139	29 Jul 74
0002	Projectile Body 07609-41005-14	250	17 Dec 73
0003	Base Plug 07609-40890	250	17 Dec 73
0004	Cavity Liners 07609-40727 Rev. B	951	17 Dec 73
		1,049	26 Apr 74

* Reworked Due to Damage During Initial Shipment.

3.2 Scrap Rates

3.2.1 The aforementioned 3.5% reject rate in the cold drawing operations was attributed primarily to material inclusions. The Company cut 5,800 forge slugs and shipped 5,239 projectile bodies (including Puff rounds) for a dropout rate of 561 bodies, or 9%. This is not out-of-line when using non-production equipment. Most of the equipment available is the multi-purpose, free setup type. Parts generally are lost in setup, from operator error, and from usage of temporary tooling which does not have the tolerancing or the wear qualities of permanent tooling. In the production situation, permanent tooling is placed in single-purpose equipment and the operator factor is reduced to a minimum.

3.2.2 The major areas of dropout were as follows:

- I.D. to O.D. concentricity out more than .026 inch (50 pieces)
- Undersize bourrelet diameter
- Undersize boattail datum diameter
- Oversize nose thread
- Undersize band seat diameter
- Parts burned severely in setup of base cover welder

On the latter item it was determined that the base cover welder control was at fault and it was repaired.

The nose threads were Class II. Those rejected passed a Class I gage. Tool wear had a bearing on whether threads would meet Class II requirements or not.

3.3 Production Estimates

Because of materials and labor price escalations since the preceding contract, the cost per item in production also has escalated. Using 9260 steel, at a rate of 10,000 to 20,000 per month via the hot cup-cold draw process, the following applies per projectile metal parts set:

$18 to $20 per unit

The above is a low monthly production rate price, and would decrease if quantities increased and multi-year procurements were instituted. The price would not apply on an initial procurement where tooling, gages, and ancillary equipment must be procured, and a learning curve must be completed.

4. CONCLUSIONS

4.1 When processing the 76-mm/62 Caliber Projectile from 9260 steel by the hot cup-cold draw process, material inclusions and other imperfections in the basic bar present a problem. Almost certainly if an imperfection is present the part will crack during a cold drawing operation. Chamberlain has no means of knowing whether the bulk of steel furnished for the contract was procured to a specified maximum inclusion rate, or whether only normal commercial specifications applied.

4.2 Bar ends upset and deformed by the nick-and-break method prevented optimum usage of all available steel for the first 1,500 forge slugs. Any attempt to use a deformed forge slug would have presented problems in centering in the die, abnormal grain flow in the forged part, a rise in cold drawn cracked bodies, and inconsistent mechanical properties within individual projectile bodies. Sawed bars did not present these problems.

5. RECOMMENDATIONS

5.1 Revise the drawings to eliminate the hardness requirement, and stipulate that bodies should be heat treated to a range of mechanical properties, or vice-versa, whichever is more compatible with ballistic performance. If mechanical properties are stipulated, hardness should be advisory.

5.2 To ease manufacturing and tooling costs, the band seat configuration should be revised to a standard United States seat.

5.3 Clarify on the drawings that the nose thread should go all the way through to preclude ambivalent interpretations.

5.4 Reduce the 100% hydrostatic pressure test requirement to an AQL requirement. Chamberlain never has had a leaker by the hot cup-cold draw process.

5.5 Consider investigation of the hot forge-hot draw process as a means of overcoming cracking induced by material inclusions. Otherwise, specifications for 9260 steel will have to be rather restrictive -- a situation which would increase the production cost of the projectile.